DISTRIBUTIONS OF REAL-WORLD VEHICLE TRAVEL

Project ID: VAN036
VTO Annual Merit Review, June 22, 2022

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PROJECT OVERVIEW

Objective: Improve information needed to compare economics of vehicle operation across multiple vehicle technologies in a balanced manner, accounting for variation in travel and ownership behavior

Timeline:
- Project start: October 1, 2019
- Project end: September 30, 2022
- Percent complete: 80%

Budget:
FY2020-2022: $150k/year, 100% DOE

VTO barriers addressed by this project:
- "Fill gaps or deficiencies in the analysis toolset based on the best publicly available, up to date techno-economic assessments." (ISATT roadmap, 2018)
- "Inconsistent data, assumptions, and guidelines." (FPITT roadmap, 2017)

RELEVANCE

- Driving behavior is not homogenous, and using a single mileage schedule for all calculations related to lifecycle emissions, cost of ownership, and vehicle survivability does not yield a full understanding of fleet wide fuel consumption.
- Vehicle choice models used for analysis and for policymaking strongly rely on assumptions about vehicle miles traveled (VMT) and vehicle lifetime.
- Optimal vehicle choices from a levelized cost of driving standpoint may vary depending on differing use cases.
- New technologies are more likely to be useful to a subset of consumers before the whole market, e.g., a battery electric vehicle driven more intensively than the average may have an easier time reaching cost parity than a "typical" vehicle.

APPROACH

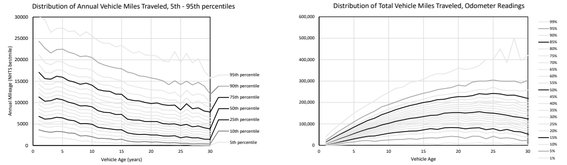
- Quantify variations in vehicle miles traveled (VMT), considering vintage, vehicle characteristics, and demographic characteristics
- Quantify levelized cost of driving (LCOD) for vehicles with different use intensities
- Estimate how variations in VMT impact national-scale metrics such as fuel consumption and emissions, both for today's vehicles and potential future scenarios
- Assess variations in vehicle survivability to determine typical length of time that different types of vehicles stay on the road.

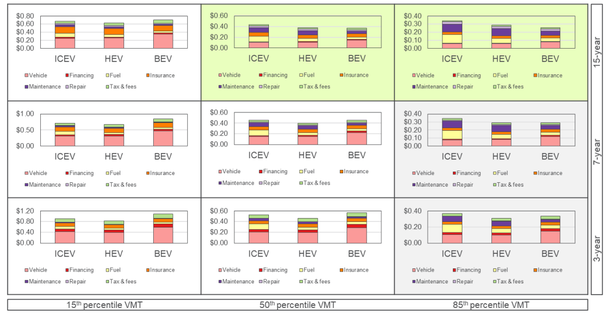
PARTNERSHIPS AND COLLABORATIONS

- This project informed VTO's Total Cost of Ownership research project (FY2020, VAN038), and links into ANL's VISION modeling (VAN033). High-fidelity vehicle operating cost modeling is from an ongoing project funded by EERE's Strategic Analysis program.
- Vehicle registration data acquired from Experian Automotive.
  Heavy-duty truck vehicle operational data gathered from California Department of Transportation through California Vehicle Inventory and Use Survey / Caltrans Truck Survey (CA-VIUS).

TECHNICAL ACCOMPLISHMENTS: VMT DISTRIBUTIONS AND TCO

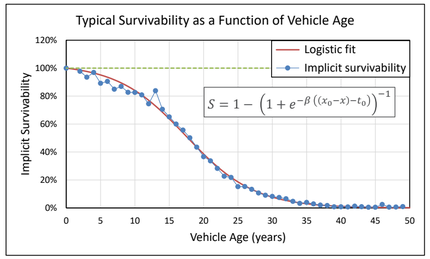
- Given VMT distributions (shown below, analyzed in earlier years of this project), able to quantify variations in total cost of ownership (TCO) for different usage paradigms.
- Graphic to right shows TCO for conventional internal combustion engine (ICE) SUV, hybrid electric vehicle (HEV), and battery electric vehicle (BEV), **based on vehicles sold in 2019**.
- Columns and rows are 15th, 50th, and 85th percentile for VMT for a typical small SUV, and a 3-year, 7-year, and 15-year ownership window.
- HEV always lower cost than ICEV. BEV cheapest for most drivers at 15 years (shaded in green), cheaper than ICEV within 3 years for intense drivers (shaded in light gray).





TECHNICAL ACCOMPLISHMENTS: VEHICLE SURVIVABILITY

- Comparing vehicle registrations with initial vehicle sales, we can estimate survivability of vehicles dating back to the 1970s.
  - We assume a logistic curve, following seminal work by Greene and others.



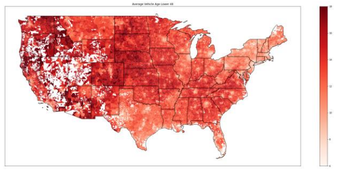
- Typical vehicle survivability rates depend on the vehicle size class and powertrain.
- HEV have a longer lifetime than ICEV. PHEV and BEV exhibit a shorter lifetime, but this may be an artifact of the data fitting (only 10 years of EV sales data).
- Pickup trucks have a much longer expected lifetime than cars, with SUVs in between.

	Median Lifetime (years), t_0	Rate Factor, β	Model years
All vehicles	17.6	0.199	1972 – 2019
HEV	18.3	0.152	2000 – 2019
PHEV	10.7	0.632	2011 – 2020
BEV	13.4	0.183	2011 – 2020

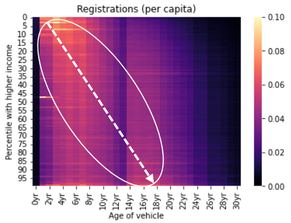
	Median Lifetime (years), t_0	Rate Factor, β	Model years
All vehicles	17.6	0.199	1972 – 2019
Car	16.2	0.200	1972 – 2019
Pickup	22.1	0.166	1973 – 2019
SUV	18.6	0.197	1976 – 2019
Van	16.2	0.232	1983 – 2019

TECHNICAL ACCOMPLISHMENTS: GEOGRAPHICAL VEHICLE DIFFUSION

- Average age of vehicles varies across U.S.
  - Lowest ages in Northeast, highest in Midwest
  - Lower vehicle ages near urban centers

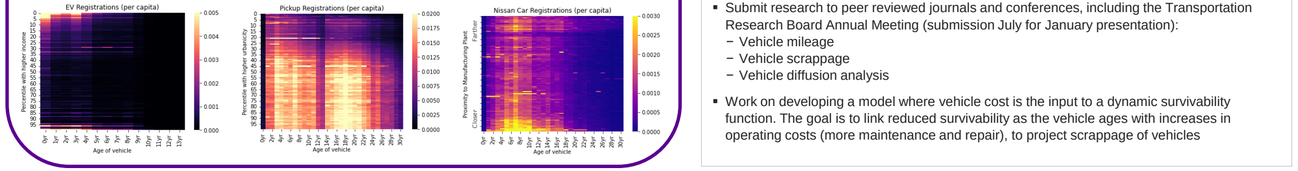


- Considering vehicles at the zip code level, we look at the *distribution* of vehicle ages



- In the heat map to the left, zip codes are sorted by income (high-income zip codes on the top) and vehicle registrations are disaggregated by vintage is on the horizontal axis (newer vehicles on left). Brighter colors represent groups with a higher number of total vehicle registrations per household.
- Higher income zip codes tend to have newer vehicles, and older vehicles diffuse through to lower-income locations (top left to bottom right)

- Electric vehicles are particularly prominent in high-income zip codes. We consider other correlations than just income. Pickup trucks are a predominantly rural vehicle, especially for older models. Looking at automakers, we find a clear increase in vehicle registrations in proximity to OEM manufacturing plants.



MILESTONES SINCE LAST ANNUAL MERIT REVIEW

Month/Year	Description	Status
June 2021	Report for TRB Annual Meeting: Distributions of VMT by household and vehicle characteristics	Complete*
June 2021	Presentation comparing levelized cost of driving for different use segments	Complete
Sep 2021	Documentation report on analysis of scrappage rates as a function of vehicle characteristics	Complete
Dec 2021	Identification of data sources for medium/heavy-duty vehicle usage distributions	Complete
Mar 2022	Geographical linkage of vehicle registration throughout vehicle lifetime, incorporating supply chain and used vehicles	Complete
Jun 2022	Development of integrated TCO/survivability model	On track
Sep 2022	Cost parity and energy analysis for different powertrains and vehicle use cases	On track

*Accepted for presentation, but withdrawn due to COVID-19 travel restrictions.

RESPONSES TO REVIEWER FEEDBACK

- Reviewers noted the potential lack of data for MHDV. Data has been acquired from CalTrans for use in future research projects.
- Reviewers noted potential difficulties in finding operational and ownership data for LDV. For VMT data, this continues to be difficult, but ANL has since acquired detailed registration data to better understand vehicle age distributions at a finer geographic level.
- Reviewers noted clear connections of this research with other VTO-sponsored research, but requested deeper connections with specific researchers across the laboratory system to help strengthen the research.
- Reviewers noted the interest in broader publications. Results were intended to be shared at TRB Annual Meeting in January 2022, but paper was withdrawn due to travel restrictions. Publication and dissemination of results continues to be a high priority.

SUMMARY & NEXT STEPS

- Vehicles are not used homogenously, so it is important to account for variations
  - Differences by vehicle type, geography, fuel economy, powertrain
- Increased vehicle travel can make alternative fuel vehicles with lower operating costs but higher purchase costs more cost-effective, which can have a magnified impact for reducing fuel consumption or emissions
- Submit research to peer reviewed journals and conferences, including the Transportation Research Board Annual Meeting (submission July for January presentation):
  - Vehicle mileage
  - Vehicle scrappage
  - Vehicle diffusion analysis
- Work on developing a model where vehicle cost is the input to a dynamic survivability function. The goal is to link reduced survivability as the vehicle ages with increases in operating costs (more maintenance and repair), to project scrappage of vehicles

This presentation does not contain any proprietary, confidential, or otherwise restricted information.
Any proposed future work is subject to change based on funding levels.

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